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1. Introduction

This survey is concerned with the international interdependence and coordination of the monetary policies of different economies under alternative exchange-rate regimes. The focus of attention and the interpretation of the results will, as much as possible, be on the European economies. There will be three exchange-rate regimes considered: (i) fixed exchange rates; (ii) managed exchange rates; (iii) floating exchange rates.

A regime of irrevocably fixed exchange rates is not that different from full monetary union with a common currency unit. It implies that each central bank has no control of its money supply, because it is very much determined by the balance of payments. In fact, under full employment (or under indexation of the nominal wage to the cost-of-living index) monetary policy is neutral and has no real effects. Hence, under such a long-run view, one can focus on the international conflicts that arise from the observation that domestic credit expansion leads to a bit more inflation for the whole region and a balance-of-payments deficit. Section 2 focuses on these problems and, in particular, on the coordination problems that arise when each central bank cares about inflation and foreign reserves. Maintaining a long-run view with a clearing labour market, Section 3 then discusses the potential for the international coordination of monetary policies under floating exchange

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rates. Of course, the main difference from Section 2 is that each central bank can conduct its own monetary policy and can thus control its own inflation rate. Section 3 focuses on two channels of transmission. The first one is a public-finance view, which says that any change in monetary policy must be accompanied by a change in distortionary taxes and therefore has real effects. The second one relies on the interdependent Mundell–Tobin effect, which argues that an increase in monetary growth reduces the world real interest rate and therefore increases capital accumulation in all countries.

Section 4 considers the international coordination of monetary policy under floating exchange rates, and concentrates on the effects on the exchange rates and on employment and output. Section 5 discusses the spill-over effects under fixed exchange rates. Section 6 discusses the characteristics of international coordination of a regime of managed exchange rates, such as the European Monetary System. The idea is that Germany chooses its money supply to maximize German welfare whilst the other countries of Europe choose their optimal realignments of their currencies *vis-à-vis* the Deutschmark to maximize their welfare. Section 7 presents a brief summary of the results.

2. Fixed Exchange Rates, Full Employment and the Problem of Inflation and the Balance of Payments

The first study to analyse issues of monetary policy coordination with the aid of the monetary approach to the balance of payments was Hamada (1976). This is a classic and serves as a useful example of how modern economic theory approaches the problem of international policy coordination.

Under fixed nominal exchange rates monetary policies are closely interdependent. This also occurs when exchange rates between the participating countries are fixed (as they are for periods of time in the European Monetary System), but when the central banks of the participating countries are not yet completely unified. Even when there is full monetary union or one global central bank (such as the proposed European Central Bank), it is of importance to know what incentives member countries have when they decide on their monetary policies in a non-cooperative fashion and when they decide in a cooperative of coordinated fashion. The monetary approach to the balance of payments assumes full employment and purchasing power parity or commodity arbitrage. The latter assumption implies, under fixed exchange rates, that there is a common rate of inflation in all countries, say π. A surplus (deficit) in the balance of payments occurs when the demand for money of a country exceeds (falls short of) the domestic supply of money, $\dot{m}_i = (x_i + \dot{y}_i) + z_i$ where m_i denotes the growth rate in the nominal money

stock, $\dot{y}_i$ denotes the growth rate in real income, x_i denotes the difference between domestic credit expansion and real growth, and z_i denotes the balance of payments as a ratio of the nominal money stock for the i-th member state. The quantity theory gives the following condition for equilibrium in the money market, $\dot{m}_i - \pi = \dot{y}_i$. The weighted sum of the balances of payments, $\sum_{i=1}^{N} w_i z_i$ where N denotes the number of member states and w_i denotes the share of money demand for country i in world money demand, must equal the increase in international reserves as a ratio of world money demand, say G_R. It then follows that:

(i) There is a common or world rate of inflation (π) given by the weighted average of the excess growth rates in the supply of domestic credit expansion over the growth rates in real income in each of the member states (x_i) *plus* the increase in international reserves as a ratio of the total world money supply (G_R).

(ii) One country's surplus on the balance of payments must be another country's deficit or, more precisely, the balance of payments of each member state expressed as a ratio of its demand for money (z_i) is the difference between the weighted average of excess supplies of domestic credit of all member states together and its own excess supply of domestic credit.

In algebraic terms, this can be summarized by:

$$\pi = \sum_{i=1}^{N} w_i x_i + G_R \tag{2.1}$$

$$z_i = \pi - x_i, \; i = 1, 2, \ldots, N. \tag{2.2}$$

Hence, an expansion of domestic credit in one country leads to a deficit on the balance of payments in that country, which is mirrored by surpluses on the balance of payments in the other countries, and to higher inflation in all countries. It is clear that the policies of each central bank affect the outcomes in the other countries, so there are strong international spill-over effects. It should be no surprise therefore that the setting of monetary policies is a highly interdependent problem and has aspects of a game between the various central banks.

National monetary policies are guided by cost-benefit calculations of the monetary authorities. To be precise, the central bank of country i chooses its domestic monetary policy (x_i) to minimize its welfare-loss function, which depends on inflation and the desired change in foreign reserves (i.e. the balance of payments):

$$\min_{x_i} W_i \equiv \tfrac{1}{2}(\pi - \pi^d)^2 + \tfrac{1}{2}\alpha_i(z_i - z_i^d)^2, \tag{2.3}$$

where π^d and z_i^d denote the desired or bliss values of inflation and the balance of payments and α_i denotes the weight given to the balance-of-payments target by country i. Non-cooperative (or Nash–Cournot) policies are obtained when each central bank takes the policies of the other central bank as given when deciding on its own optimal policy. Using (2.1)–(2.2) and $\partial W_i/\partial x_i = 0$, one obtains

$$w_i(\pi - \pi^d) = \alpha_i(1 - w_i)(z_i - z_i^d), \tag{2.4}$$

so that the marginal rate of substitution between inflation and the balance of payments ($w_i/(1 - w_i)$) is large for a large country. Also, smaller countries have a stronger effect on their balance of payments than on inflation. When a country wishes to reduce inflation, it sacrifices its balance-of-payments target and thus incurs more surplus than is desirable ($\pi > \pi^d \Leftrightarrow z_i > z_i^d$).

Cooperative monetary policies are assumed to be the outcome of international policy coordination. They follow from choosing jointly the monetary policies of all central banks to maximize global welfare, say minimize $W \equiv \Sigma_{k=1}^N \beta_k W_k$, $\Sigma_{k=1}^N \beta_k = 1$, $\beta_k \geqslant 0$ where β_k denotes the index of bargaining power for country k. Economists refer to such policies as Pareto-efficient outcomes when it is ensured that none of the countries is worse off and at least one is better off. It is easy to show that the Pareto-efficient rate of inflation corresponds to the desired rates of inflation ($\pi = \pi^d$), because summing the first-order conditions, $\partial W/\partial x_i = \Sigma_{k=1}^N \beta_k w_i[(\pi - \pi^d) + \alpha_k (z_k - z_k^d)] - \beta_i \alpha_i (z_i - z_i^d) = 0$, $i = 1, \ldots N$ yields $\pi = \pi^d$ immediately. Summing (2.4), one obtains for the non-cooperative outcome:

$$\pi - \pi^d = \sum_{i=1}^{N} \alpha_i (1 - w_i)(z_i - z_i^d). \tag{2.5}$$

When the right-hand side of (2.5) is negative (positive), international reserves and credit expansion are public goods (bads) and therefore give a deflationary (inflationary) bias to the non-cooperative outcome, because each central bank welcomes a higher (lower) growth in the world money supply whilst it attempts to expand its own money supply at a slower (faster) rate than the other central banks. It is now straightforward to establish the following propositions (Hamada, 1976). The non-cooperative outcome gives an inflation rate higher (lower) than the desired rate of inflation when the increase in international reserves, G_R, exceeds (falls short of) the weighted

average of desired increases in international reserves, $\Sigma_{i=1}^{N} w_i z_i^d$. The reason is that, if $\pi > \pi^d$, then from (2.4) each country will have $z_i > z_i^d$ and thus $\Sigma_{i=1}^{N} w_i z_i = G_R > \Sigma_{i=1}^{N} w_i z_i^d$. Hence, when there is an excessive (a too low) expansion of world reserves, international policy coordination implies that central banks reduce (increase) their rates of expansion in domestic credit. In other words, when the expansion of international reserves is excessive, countries defend themselves against reserve accumulation by expanding domestic credit and thus increasing world inflation above the desired level. Countries defend themselves by exporting inflation to abroad. The increase in the size of the group of member states works, as is well known from the theory of public choice, against the optimal supply of public goods and thus of credit expansion. Hence, when the number of countries increases, the non-cooperative outcome diverges more from the cooperative outcome.

The design of a successful system of fixed nominal exchange rates must be such that the non-cooperative or nationalistic outcome is not too different from the outcome under international policy coordination. The main lesson is that this requires one to manipulate the increase in international reserves in such a way as to match the average preference for accumulating reserves by the central banks. This requirement for success becomes more essential as the number of member states increases.

The results in this Section are most relevant for a system of irrevocably fixed exchange rates as would be the case for a monetary union. The results are less relevant for a regime of managed exchange rates, such as the European Monetary System, because then the French, Italian, Belgium and Dutch central banks are allowed to have periodic realignments of their exchange rates (also see Section 6).

3. Floating Exchange Rates and Full Employment

In an international regime of floating exchange rates and, for the time being, full employment in each member state, exchange rates adjust to clear the balance of payments in each country ($z_i = 0$) and therefore inflation in each country (say, π_i) is given by the excess rate of growth in domestic credit expansion in that country ($\pi_i = x_i$). It follows that each country can conduct an independent monetary policy and choose its own, individual inflation rate. The lack of international spill-over effects suggests that there is no big role for international policy coordination, since inflation in each country is simply set to its desired value ($\pi_i = \pi_d^i$) both under non-cooperative and under cooperation policymaking.

However, the models considered so far ignore three essential features of Western economies. The first feature is the public-finance aspect of

monetary policy, the second feature is the effect of monetary policies on real interest rates and capital accumulation, and the third feature is the effect of monetary policy on real wages and unemployment. The first two features are discussed in the remainder of this section, whilst the third feature is discussed at some length in the next Section.

3.1. The Problem of Distortionary Taxes

Consider a system of interdependent monetary economies with floating exchange rates, full employment, exogenous levels of government spending and distortionary taxes on production income. It will be assumed that increases (decreases) in monetary growth must be accompanied by decreases (increases) in the tax rate in order for the government budget constraint to be satisfied. This allows the public-finance aspects of monetary policy to be discussed. For the time being, holdings of home and foreign bonds are ignored. This may be reasonable when there are controls on international capital movements. The demand for money is a decreasing function of the expected inflation rate, since when inflation is expected to be high agents will want to buy goods today rather than tomorrow. The first-best optimum for the world economy can be characterized by:

(i) zero tax rates on production income in all economies;
(ii) the marginal rates of substitution between home and foreign consumption of home, public and foreign goods must be unity;
(iii) the marginal utilities of money balances in each country must be zero or, alternatively, Friedman's optimal quantity of money must prevail in each country.

Unfortunately, this first-best outcome can not be obtained in an international and interdependent system of decentralized market economies but it serves as an appropriate benchmark.

A decrease in home monetary growth implies an increase in the home tax rate, which reduces the opportunity cost of leisure and thus cuts the supply of labour and goods. It also dampens home consumption of home and foreign goods. The resulting surplus on the current account of the balance of payments induces an appreciation of the real exchange rate, which dampens foreign consumption of home goods and therefore worsens foreign welfare. Hence, a decrease in home monetary growth or an increase in home taxes is a *beggar-thy-neighbour* policy as far as welfare is concerned. (The effect on home welfare is ambiguous, because home consumption fall whilst leisure increases.) Given this international externality, it is straightforward to show that (see van der Ploeg, 1988):

(i) The non-cooperative outcomes are inefficient, because the negative effects of higher taxes on foreign welfare are not internalized and therefore tax rates and levels of government spending are too high in the non-cooperative equilibrium.

(ii) International policy coordination would lead the governments of each country to increase monetary growth rates, reduce tax rates and reduce levels of government spending, which leads to higher consumption of home and foreign goods, to lower seigniorage revenues and to a level of real money balances below (rather than above as under the non-cooperative equilibrium) Friedman's optimal quantity of money.

(iii) Both the non-cooperative outcome and the outcome under international policy coordination are inefficient, because there are positive tax rates leading to real distortions, to deviations from Friedman's optimal quantity of money, and to a too low provision of public goods.

So far, the entire discussion has assumed that central banks have a reputation with their private sector. The Appendix gives more detail and also looks at the case where central banks cannot pre-commit themselves. Note that under fixed exchange rates, the scope for raising seigniorage revenues is much less and therefore the public-finance aspects of international policy coordination become even more relevant.

3.2. The Problem of Capital Accumulation

Let us now move on to the second feature associated with the effects of monetary policy on the real interest rate and capital accumulation (see van der Ploeg, 1987). Now consider an interdependent system of monetary economies with floating exchange rates, full employment, exogenous levels of government spending, perfect capital mobility, investment and capital accumulation. Financial markets in the world economy are nowadays highly integrated, which implies that international movements in bonds are highly mobile. Hence, (risk-neutral) arbitrage between home and foreign assets ensures that the real returns on home and foreign bonds are equalized in the long run so that we can talk about a common world real interest rate. This observation leads to the interdependent Mundell–Tobin effect, that is an increase in home monetary growth leads to a less than proportionate increase in the home nominal interest rate and a fall in the world real interest rate and thus to increases in investment and capital accumulation in each country. Each central bank wishes on the one hand to cut monetary growth in order to attain the inflation objective and on the other hand to increase monetary

growth in order to boost capital accumulation, employment and output. A decrease in home monetary growth is again a beggar-thy-neighbour policy, because it raises the world real interest rate and depresses activity and therefore welfare in all foreign countries whilst it does not decrease foreign inflation rates. It follows that the non-cooperative outcome leads to too low levels of monetary growth and inflation throughout the world, to too high levels of the world real interest rate, and to too low levels of employment and output throughout the world.

The lack of international policy coordination leads to an international stale-mate because none of the central banks wants to carry the full burden of higher inflation associated with doing the public good of reducing the world real interest rate and increasing world activity. The point is that the cost of the charitable unilateral act of increasing monetary growth leads to inflation at home, whilst the rival countries get a 'free' increase in capital, employment and output as they do not experience an increase in inflation. Note that this coordination problem is typical of an international regime of floating exchange rates, because under fixed exchange rates there is a common inflation rate throughout the world and therefore the costs as well as the benefits of reducing the world real interest rate are shared by all of the countries concerned. Hence, the aspects and problems of international policy coordination originating from the effects of monetary policy on the world real interest rate and capital accumulation are much less relevant under fixed than under floating exchange rates. This could be considered as an advantage of an international regime of fixed exchange rates.

4. Floating Exchange Rates and the Problem of Unemployment

Let us now move on to the third feature of international coordination of monetary policies under floating exchange rates, that is the effects of monetary policy on wage formation and unemployment both at home and abroad. This feature is obviously much more concerned with the short and medium run and is, given the tremendous problem of unemployment facing most Western economies at the present, a very pressing issue.

There are of course many causes of unemployment such as a lack of effective aggregate demand, too high and rigid nominal wages, too high and rigid real consumers' wages, too little productive capacity, too high tax wedges, too much union power, an uncompetitive real exchange rate, etc. We have already discussed in the previous section the effects of monetary policy on the real interest rate and productive capacity and the consequent need for international policy coordination. Here we focus on the effects of

monetary policy on aggregate demand and the real exchange rate. We will assume that nominal wages are rigid and too high in the short run, even though they can adjust in the long run to ensure that unemployment reaches its natural rate. We could also have assumed that real wages are rigid and too high in the short run, but in the absence of wealth effects monetary policy has then no real effects as prices, wages and the nominal exchange rate change proportionally and thus leave employment and output unaffected. However, in a situation of real wage rigidity the international coordination of fiscal policies is an important problem and is independent of the nature of the exchange-rate regime in place (van der Ploeg, 1989).

To focus our ideas, consider a simple symmetric, two-country, monetary, short-run model with floating exchange rates, immobility of labour, perfect capital mobility and, for simplicity, static expectations:

$$y = -\bar{\alpha}r + \bar{\delta}(p^* + e - p) + \bar{f} + \gamma y^*, \; 0 \leqslant \gamma < 1, \tag{4.1}$$

$$y^* = -\bar{\alpha}r^* - \bar{\delta}(p^* + e - p) + \bar{f}^* + \gamma y, \; \bar{\alpha} > 0, \; \bar{\delta} > 0, \tag{4.2}$$

$$m - p = y - \lambda r, \tag{4.3}$$

$$m^* - p^* = y^* - \lambda r^*, \; \lambda > 0, \tag{4.4}$$

$$r = r^*, \tag{4.5}$$

$$p = w + \tau, \tag{4.6}$$

$$p^* = w^* + \tau^*, \tag{4.7}$$

where y, $\bar{f}$, r, p, e, w, m, and τ denote real output, a fiscal shock, the interest rate, the price level, the nominal exchange rate (price of foreign exchange in terms of domestic currency), the exogenous (and rigid) nominal wage, the exogenous money supply and the exogenous tax wedge respectively. All variables are percentage derivations from their steady-state values, except for r and τ. Foreign variables are distinguished with an asterisk. Equations (4.1) and (4.2) denote the home and foreign IS-curves and show that aggregate demand is a decreasing function of the interest rate and an increasing function of the real exchange rate, fiscal shocks and foreign income. Equations (4.3) and (4.4) denote the home and foreign LM-curves, which show that the real money supply must equal real money demand and that the latter depends positively on income and negatively on the interest rate. It is assumed that changes in the money supply are due to open market operations and that additional government spending and tax cuts are financed by

bonds. Equation (4.5) captures perfect capital mobility, so that returns on home and foreign bonds are equalized. Finally, equations (4.6) and (4.7) show that prices are a mark-up on wages inclusive of taxes.

Upon substitution of equation (4.6) into equation (4.3), one obtains the aggregate supply (AS–) schedule:

$$y = m - w - \tau + \lambda r \tag{4.8}$$

and similarly for the foreign country (see Figure 1). Hence, for a given nominal wage, the AS-schedule slopes upwards as a higher interest rate chokes off money demand and thus allows a higher level of income to restore equilibrium in the money market. Alternatively, a higher interest rate reduces the demand for money which exerts an upward pressure on prices, erodes the real wage and boosts aggregate supply. An increase in the nominal supply or a cut in taxes shifts the AS-schedule outwards. Combining (4.1) and (4.2) together with (4.5) yields the aggregate demand (AD–) schedule:

$$y = -\sigma r + \delta(p^* + e - p) + f + \gamma f^* \tag{4.9}$$

where $\sigma \equiv \bar{\sigma}/(1-\gamma)$, $\delta \equiv \bar{\delta}/(1+\gamma)$ and $f \equiv \bar{f}/(1-\gamma^2)$. Equating aggregate demand, (4.9), with aggregate supply, (4.8), yields the goods market equilibrium (GME) locus (see Figure 1) and similarly for the foreign country. The GME-locus slopes upwards ($\partial r/\partial c/_{GME} = \delta/(\sigma + \lambda)$), because a high interest rate leads to a low level of aggregate demand and a high level of aggregate supply of home goods which induces a fall in the relative of price of home goods or a real appreciation of the home exchange rate.

Now consider a decrease in the home nominal money supply. This reduces

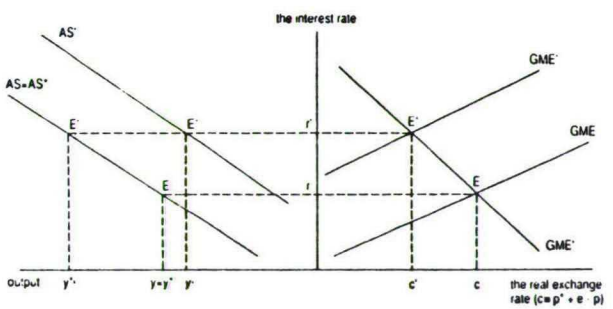

Figure 1. Effects of a cut in the home nominal money supply in a two-country model with floating exchange rates and nominal wage rigidity.

the aggregate supply of home goods, so that the AS-schedule shifts inwards and the GME-locus shifts upwards (see Figure 1). The equilibrium shifts from E to E'. Hence, the incipient excess demand for home goods is choked off by a rise in the world interest rate. The resulting incipient excess supply of foreign goods is choked off by a depreciation of the foreign real exchange rate. The main point to notice, however, is that a monetary contraction is no longer a beggar-thy-neighbour policy as in the previous section, but has a negative effect on home employment and output and a positive effect on foreign employment and output. This is accompanied by a fall in net exports of the home country. Alternatively, one has the familiar Mundell–Fleming result that a *monetary expansion is a beggar-thy-neighbour policy as far as employment and output is concerned.* The algebraic solution to the model (4.1)–(4.7) confirms the above analysis:

$$r = r^* = \tfrac{1}{2}[(1+\gamma)(f+f^*) - (m-w-\tau) - (m^*-w^*-\tau^*)]/(\sigma+\lambda) \tag{4.10}$$

$$c \equiv p^* + e - p = \tfrac{1}{2}[(m-w-\tau) - (m^*-w^*-\tau^*) + (1-\gamma)(f^*-f)]/\delta \tag{4.11}$$

$$y = \tfrac{1}{2}[(2\sigma+\lambda)(m-w-\tau) - \lambda(m^*-w^*-\tau^*) + (1+\gamma)\lambda(f+f^*)]/(\sigma+\lambda). \tag{4.12}$$

The central bank of each country conceivably wants on the one hand to increase output whilst on the other hand it wants to increase the money supply as little as possible for this leads in the long run to higher wages and prices. This is captured by the following welfare-loss function for the home central bank:

$$\underset{m}{\text{Min}}\ W \equiv \tfrac{1}{2}(y-y^d)^2 + \tfrac{1}{2}\theta m^2,\ \theta, y^d \geqslant 0, \tag{4.13}$$

where y^d denotes the full-employment value of output and θ denotes the weight attached to the price target. Initially there is too much unemployment ($y^d = y^{d*} > 0$), which may be caused by a common adverse supply shock ($w+\tau = w^*+\tau^* < 0$) or by an adverse demand shock at home or abroad ($f+f^* < 0$). This leads from (4.12) and $\partial W/\partial m = 0$ to the following reaction function for the home central bank:

$$m = \hat{\sigma}(y^d + \hat{\sigma}\hat{\lambda}m^*)/(\hat{\sigma}^2+\theta),\ \hat{\sigma} \equiv \left(\frac{\sigma+\tfrac{1}{2}\lambda}{\sigma+\lambda}\right),\ 0 < \hat{\lambda} \equiv \lambda/(2\sigma+\lambda) < 1. \tag{4.14}$$

Hence, more initial unemployment (a higher value of y^d) leads to a high money supply. Also an increase in the foreign money supply leads to more home unemployment and thus the home central bank reacts with an increase in its money supply. Intersection of (4.14) with the foreign reaction curve leads to the non-cooperative (or Nash–Cournot) outcome, say m_N. The cooperative outcome, say m_C, follows from choosing m and m^* to minimize the global welfare loss, $W + W^*$, that is $\partial(W + W^*)/\partial m = \partial(W + W^*)/\partial m^* = 0$. It is easily established that:

$$m_N = \left(\frac{\hat{\sigma} y^d}{\hat{\sigma}^2(1-\hat{\lambda}) + \theta}\right) > m_C = \left(\frac{\hat{\sigma} y^d}{\hat{\sigma}^2(1-\hat{\lambda}) + \theta(1-\hat{\lambda})^{-1}}\right). \qquad (4.15)$$

This leads to the following propositions for an international regime of floating exchange rates and perfect capital mobility:

(i) The non-cooperative outcome leads to a too expansionary monetary policy and thus to too low interest rates and to too high levels of employment and output, because each central bank ignores the adverse consequences of a high money supply on the other country.
(ii) International policy coordination would lead all countries to pay more attention to their inflation objectives and thus to reduce their money supplies.

Hence, in contrast to the longer-run aspects of international coordination of monetary policies to do with public finance and with the global real interest rate and capital accumulation discussed in the previous section, lack of international policy coordination implies a too expansionary (rather than a too tight) monetary stance. Canzoneri and Gray (1985) use a similar welfare-loss function and also find that the non-cooperative policies are too expansionary. They also look at the case where one of the countries, say the US in the era of floating exchange rates, adopts a (Stackelberg) leadership position *vis-à-vis* the rest of the world. This implies that the US minimizes its welfare loss subject to the reaction functions of the rest of the world and therefore the US restricts its money supply by more than the rest of the world. The interesting feature is that a non-cooperative world with US hegemony Pareto-dominates the non-cooperative (Nash–Cournot) world without US hegemony. This suggests that altering the 'rules of the game' may be a partial substitute for international policy coordination. (In fact, it can be shown that the situation where the rest of the world fixes the exchange rate, i.e. where the rest of the world chooses exactly the same money supply as the US, is preferred to the US hegemony outcome by the US but not necessarily by the rest of the world.)

In the 1970s inflation was a very important problem for policymakers in

the Western world and, not surprisingly, many central banks engaged in monetary disinflation. For example, the Medium Term Financial Strategy adopted in the UK economy under Mrs Thatcher attempted to implement gradual reductions in the UK monetary growth rate. Many studies have analysed the potential for international coordination of monetary disinflation programmes (e.g. the papers by Oudiz and Sachs and by others in Buiter and Marston, 1985). These studies have applied differential or difference game theory to multiple-country versions of Dornbusch's (1976) famous real-exchange-rate overshooting model, which extend the model discussed earlier in this section by replacing the assumption of a rigid nominal wage by an augmented Phillips curve, thereby ensuring that unemployment returns to its natural rate in the long run, and by allowing for rational expectations in the foreign-exchange and in other financial markets. In such models an anticipated reduction in home monetary growth leads to an immediate appreciation of the home real exchange rate, a fall in home employment and output and an increase in foreign employment and output (reflecting the locomotive aspect of a monetary contraction discussed earlier in this Section). The policy problem of each central bank is that they start off with full employment whilst they inherit a too high inflation rate, but that the disinflation policy of cutting monetary growth leads to transient job losses. Typically, one finds that the absence of international policy coordination leads to excessively fast disinflation in all countries. Such a finding may seem counter-intuitive, because one would think that excessive disinflation is a 'public good' as far as employment and output is concerned and therefore one would think that non-cooperation would lead to an under-supply of this 'public good.' However, such arguments ignore the fact that a cut in home monetary growth leads to a depreciation of the foreign real exchange rate and consequently to a higher consumers' price level, so that monetary contraction is a beggar-thy-neighbour policy and thus a 'public bad' as far as the inflation target is concerned.

This insight can best be explained and illustrated with the aid of our simple two-country model. Imagine that the welfare-loss function of the home central bank is, instead of (4.13), given by:

$$\min_{m} W \equiv \tfrac{1}{2}(y - y^d)^2 + \tfrac{1}{2}\bar{\theta}(w - p_c - \bar{\omega})^2, \quad \bar{\theta}, \bar{\omega} > 0, \qquad (4.13')$$

where p_c denotes the (log of the) consumers' price level and $\bar{\omega}$ denotes the desired (and positive) real consumers' wage. Hence, the central bank may wish to increase the real consumers' wage or, alternatively, decrease inflation in the consumers' price index as well as increase employment and output. The consumers' price level is, under the assumption of Cobb–Douglas preferences, a weighted average of home and foreign producers' prices:

$$p_c = (1-\alpha)p + \alpha(p^* + e) = p + \alpha c, \; 0 \leqslant \alpha \leqslant 1, \tag{4.16}$$

where α denotes the share of imports in total expenditures. It follows that the reduced form of equation (4.13') can be written as:

$$\begin{aligned} \underset{m}{\text{Min}} \; & \tfrac{1}{2}[\hat{\sigma}(m - \hat{\lambda}m^*) - y^d]^2 + \tfrac{1}{2}\theta(m^* - m - \omega)^2, \\ & \theta \equiv \tfrac{1}{4}\bar{\theta}\alpha^2/\delta^2, \; \omega \equiv (2\delta\bar{\omega}/\alpha) > 0. \end{aligned} \tag{4.13''}$$

It is a straightforward exercise to use the same arguments as before and show that

$$m_N = \left(\frac{\sigma + \lambda}{\sigma}\right)[y^d - (\theta/\hat{\sigma})\omega] < m_C = \left(\frac{\sigma + \lambda}{\sigma}\right)y^d, \tag{4.17}$$

which leads to the following propositions for these more realistic welfare-loss functions:

(i) The non-cooperative outcome leads to a too tight monetary stance and thus to too much unemployment ($y_N = y^d - (\theta/\hat{\sigma})\omega < y^d$), because each central bank attempts to export inflation by appreciating its exchange rate.

(ii) The outcome under international policy coordination realizes that such competitive appreciations are futile and therefore leads to a looser monetary policy which achieves full employment ($y_C = y_C^* = y^d$).

Note that this is exactly the reverse of the outcome when the nominal money supply rather than real income or the cost-of-living index is the target variable of each central bank. A similar result is obtained by Oudiz and Sachs (1984) and by Canzoneri and Henderson (1987) and is discussed in detail by McKibbin (1987). Roubini (1986) also gets that the Nash–Cournot policies are too contractionary within the context of a three-country world and also discusses asymmetric supply shocks. The main lesson that follows from this discussion is that the nature of the bias in non-cooperative decision making and the gains from international policy coordination depend crucially on the preferences of the various governments.

So far, this Section has always assumed that a monetary expansion is a beggar-thy-neighbour policy with respect to foreign output, which is common in all analytical Mundell–Fleming models with nominal wage rigidity, floating exchange rates and perfect capital mobility. However, some argue nevertheless that a monetary expansion is a locomotive policy with respect to foreign output (e.g. Minford, 1985). The reason is that we have

been concerned with a bond-financed monetary expansion, i.e. the central banks purchase bonds from the private sector, whilst a monetary expansion could also be associated with a looser fiscal stance, i.e. lower taxes or higher government spending. Since a fiscal expansion is a locomotive policy (see equation (4.12)), it is quite possible that in empirical work a monetary expansion accompanied by a looser fiscal stance can be a locomotive rather than a beggar-thy-neighbour policy. Incidentally, this is exactly what was found in the public-finance model discussed in Section 3.1.

The discussion of Sections 3 and 4 is more relevant for transatlantic than for European coordination of monetary policies whilst Sections 2, 5 and 6 are more relevant for European policy coordination.

5. Fixed Exchange Rates and the Problem of Unemployment

We pointed out in Section 2 that the need for international coordination of monetary policies, as far as the effects on the real interest rate and capital accumulation are concerned, are much less in a regime of fixed exchange rates than in a regime of floating exchange rates, because none of the countries can isolate its inflation rate from the other inflation rates. This Section is concerned with the short-run trade-offs and short-run international spill-over effects of monetary policy in an interdependent world with perfect capital mobility and unemployment caused by rigid nominal wages.

We will adapt the model developed in Section 4 to allow for fixed, rather than for floating exchange rates. It is easy to show that a symmetric regime of fixed exchange rates, e.g. a European Monetary Union automatically sustains the cooperative outcome in the face of global supply shocks (Roubini, 1986). In this sense, a symmetric regime of fixed exchange rates is a substitute for international policy coordination. However, we assume that the foreign central bank (say, the German Bundesbank), chooses its monetary policy (m^*) whilst the home central bank (say, the Dutch, French or Italian central bank) pegs its exchange rate to the foreign currency (e). Such an asymmetric regime is in accordance with the view that the European Monetary System operates as a greater Deutschmark-zone; for a discussion of the evidence on this proposition see Giavazzi and Giovannini (1989). Obviously, this means that the home money supply (m) has become an endogenous variable. The mechanism is as follows. If there is pressure on the home exchange rate to depreciate ($e\uparrow$) arising from a balance-of-payments deficit, then the home central bank supplies home households with foreign currency in exchange for home currency in order that home households can

import the goods they want. In other words, the home central bank defends its exchange rate by buying up its own currency and selling foreign currency. It follows that a balance-of-payments deficit leads to an equal reduction in the home money supply. Similarly, if there is pressure on the home exchange rate to appreciate arising from a balance-of-payments surplus, then the home central bank exchanges foreign currency for home currency, in order to meet the need of home exporters and foreign importers, and this leads to an increase in the home money supply. Hence, the main feature of a regime of fixed exchange rates is that the central banks of Europe, other than the Bundesbank, can no longer conduct an independent monetary policy. This is the reason why the monetary policy conducted by the central bank of the Netherlands is very much determined by the monetary policy of the Bundesbank; it is almost impossible to conduct an independent monetary and exchange rate policy. However, it is possible in the short run to *sterilize* the effects of the balance of payments on the money supply. For example, a balance-of-payments surplus can be sterilized by an open market sale of bonds to the private sector of equal magnitude so that the home money supply is unaffected. Similarly, a balance-of-payments deficit can be sterilized when the central bank purchases the right amount of bonds from the private sector.

An international regime of fixed exchange rates, in the absence of sterilization policy, simply involves making the home money supply an endogenous variable and the exchange rate an exogenous variable, so that equations (4.10)–(4.12) can be rewritten in the following form (after a considerable amount of algebra):

$$r = r^* = [-\delta e - m^* + \gamma f + f^* + \delta(w + \tau) + (1 - \delta)(w^* + \tau^*)]/(\sigma + \lambda) \qquad (5.1)$$

$$m = 2\delta e + m^* + (1 - \gamma)(f - f^*) + (1 - 2\delta)(w + \tau - w^* - \tau^*) \qquad (5.2)$$

$$y = 2\hat{\sigma}\,\delta(e - w - \tau) + [\sigma m^* + ((1 - \gamma)\sigma + \lambda)f - ((1 - \gamma)\sigma - \gamma\lambda)f^* - ((1 - 2\delta)\sigma - \delta\lambda)(w^* + \tau^*)]/(\sigma + \lambda) \qquad (5.3)$$

$$y^* = -2\hat{\sigma}\,\hat{\lambda}\delta(e - w - \tau) + [\sigma m^* + \lambda(\gamma f + f^*) - (\sigma + \lambda\delta)(w^* + \tau^*)]/(\sigma + \lambda). \qquad (5.4)$$

An increase in the German money supply ($m^*\uparrow$) leads to an equal increase in the French, Italian or Dutch money supply and thus to twice as large a fall in the European interest rate as would be the case under an international regime of floating exchange rates. The reason for the increase in the non-German money supply is that the non-German central banks are defending

themselves against an appreciating currency by buying up foreign reserves and selling their own currency. Since the fixed exchange rate implies that there is no net effect on net exports arising from changes in relative prices, it is clear that employment and output in Germany and the rest of Europe increase due to the increase in consumption and investment arising from a lower interest rate in Europe. This increase in output in each country is smaller than the increase in output in Germany under floating exchange rates, because the beneficial effects on net exports of depreciating exchange rates do not occur under a regime of fixed exchange rates. The main point to remember is that a *German monetary expansion is, as far as employment and output are concerned, a locomotive (rather than a beggar-thy-neighbour) policy under a regime of fixed (rather than floating) exchange rates.*

Now consider the effects of a devaluation of the French, Italian or Dutch currency ($e\uparrow$) *vis-à-vis* the Deutschmark. This leads to an improvement in net exports of the rest of Europe to Germany and thus to an increase in non-German employment and output and to a decrease in German employment and output. To choke off the resulting excess supply of German money, the European interest rate falls and as a result the non-German money demand increases in line with the non-German money supply. Hence, *as far as employment and output is concerned, a devaluation of the French, Italian or Dutch currency is a beggar-thy-neighbour policy.* Since the world supply of money increases, the European interest falls and thus the increase of output in the rest of Europe exceeds the fall in German output and, similarly, the non-European consumers' price level increases, by more than the German consumers' price level falls. Hence, from equation (4.15) it is clear that non-German consumers' prices increase as a result of a non-German devaluation whilst German consumers' prices decrease. Hence, as far as the real-income target is concerned, a revaluation of the French, Italian or Dutch currency is a beggar-thy-neighbour policy.

6. Managed Exchange Rates, the EMS and the Problem of Unemployment

Let us now consider a regime of managed exchange rates (also sometimes called a reserve currency system), that is Germany chooses its money supply to maximize its welfare whilst the rest of Europe chooses its exchange rate *vis-à-vis* the Deutschmark to maximize their welfare. Alternatively, under Bretton Woods the US might be viewed as determining world monetary policy whilst the other countries in the world peg their exchange rates *vis-à-vis* the dollar. Under the Gold standard there was a UK hegemony. Such a regime may be more realistic than one would think at first sight even

now, because since 1980 more than 140 countries seem to be classified by the International Monetary Fund as pegging their currencies in some way or another. Hence, a regime in which countries manage their exchange rates may be more relevant in many circumstances than a regime of rigidly fixed exchange rates or a regime of a 'clean' float. It is also the case that an asymmetric exchange-rate regime is quite realistic; particularly, in the light of the 'N-1 problem' which says that not all the N countries can independently control their exchange rates as only N-1 of them are independent bilateral exchange rates (see Mundell, 1968). Until full monetary union is achieved in Europe, the European Monetary System can be viewed as an arrangement where exchange rates are neither floating nor irrevocably fixed and where the European monetary stance is almost wholly determined by the Bundesbank. Hence, this Section will be concerned with the European Monetary System rather than with full monetary union in Europe. It will be assumed that the Bundesbank has full control of the German money supply and gives up any control of the intra-European exchange rates whilst the other European central banks have full control of their exchange rates *vis-à-vis* the Deutschmark and give up any control of their money supplies.

We will also assume that the financial markets of Europe are highly integrated, so that the rates of return on the bonds issued by the various European governments must be equalized. Since the European Monetary System is a system of managed exchange rates, speculative attacks on the currency and balance-of-payments crises can occur whenever the private sector expects a devaluation of the currency. Some of the European countries, e.g. Italy and France, have used capital controls as a means of avoiding such speculative attacks. This is the reason that perfect capital mobility does not yet always hold in Europe, as can be witnessed from the differential between off-shore and on-shore interest rates. It suggests that the abolition of capital controls in Europe may not be feasible unless Europe also moves to full monetary union with irrevocably fixed exchange rates. We will abstract from such issues and thus assume that the European Monetary System is characterized by perfect capital mobility.

We will assume that each central bank is concerned about unemployment and real income (or the cost-of-living) in its own country, so that the welfare-loss function (4.13') will be used. This implies from (4.13'), (4.16) and (5.3)–(5.4) the following reduced-form welfare-loss functions:

$$\min_{e} W = \tfrac{1}{2}[2\hat{\sigma}\,\delta e + \left(\frac{\sigma}{\sigma+\lambda}\right)m^* - y^d]^2 + \tfrac{1}{2}\bar{\theta}\alpha^2[e + (\bar{\omega}/\alpha)]^2 \qquad (6.1)$$

$$\min_{m^*} W^* = \tfrac{1}{2}[-2\hat{\sigma}\hat{\lambda}\delta e + \left(\frac{\sigma}{\sigma+\lambda}\right)m^* - y^d]^2 + \tfrac{1}{2}\bar{\theta}\alpha^2[e - (\bar{\omega}/\alpha)]^2 \qquad (6.2)$$

Note that the Bundesbank has lost control over the exchange rate and has therefore lost control over its real-income target. The reaction function for the Bundesbank follows from $\partial W^*/\partial m^* = 0$. It is upward-sloping and given by

$$m^* = \left(\frac{\sigma + \lambda}{\sigma}\right) y^d + \left(\frac{\lambda\delta}{\sigma}\right) e, \tag{6.3}$$

so that it reacts with a monetary expansion when the other central banks of Europe attempt to devalue their currency and thereby cause German employment and output losses (see Figure 2). The reaction function of the non-German central banks follows from $\partial W/\partial e = 0$ and are downward sloping and given by

$$e = \left(\frac{2\hat{\sigma}\,\delta\left[y^d - \left(\frac{\sigma}{\sigma + \lambda}\right) m^*\right] - \bar{\theta}\alpha\bar{\omega}}{4\hat{\sigma}^2\delta^2 + \bar{\theta}\alpha^2} \right), \tag{6.4}$$

so that when the Bundesbank increases its money supply and thereby increases non-German employment and output as well, the other central bank can afford to pay more attention to their real-income target and thus react with a revaluation of their exchange rate *vis-à-vis* the Deutschmark (see

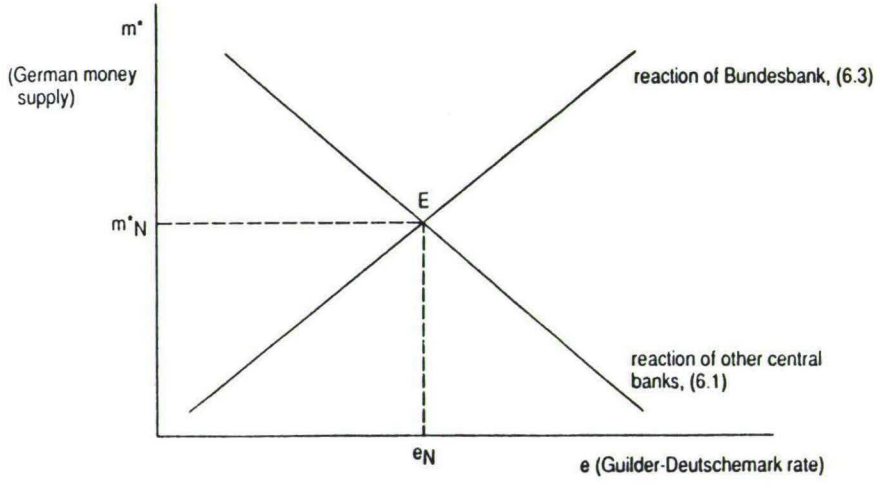

Figure 2. Reaction functions in a world of managed exchange rates.

Figure 2). The non-cooperative (or Nash–Cournot) outcome, say e_N and m_N^*, corresponds to the intersection of the reaction curves, (6.3) and (6.4) and is given by (also see Figure 2):

$$e_N = -\left(\frac{\theta}{2\delta(\theta+\hat{\sigma})}\right)\omega < 0 \tag{6.5}$$

$$m_N^* = \left(\frac{\sigma+\lambda}{\sigma}\right)y^d - \left(\frac{\lambda\theta}{2\sigma(\theta+\hat{\sigma})}\right)\omega. \tag{6.6}$$

Upon substitution of (6.5)–(6.6) into (5.1)–(5.4), one obtains:

$$m_N = 2\delta e_N + m_N^* = \left(\frac{\sigma+\lambda}{\sigma}\right)y^d - \left(\frac{(2\sigma+\lambda)\theta}{2\sigma(\theta+\hat{\sigma})}\right)\omega < m_N^* \tag{6.7}$$

$$r_N = r_N^* = -(\delta e_N + m_N^*)/(\sigma+\lambda) = -[y^d + \tfrac{1}{2}\theta(\theta+\hat{\sigma})^{-1}\omega]/\sigma \tag{6.8}$$

$$y_N = y^d - \theta(\theta+\hat{\sigma})^{-1}\omega < y^d \tag{6.9}$$

$$y_N^* = y^d < y_N. \tag{6.10}$$

It follows that the resulting welfare losses for the home and foreign country are given by:

$$W_N = \tfrac{1}{2}\theta\omega^2[(\theta+\hat{\sigma}^2)/(\theta+\hat{\sigma})^2] > 0 \tag{6.11}$$

$$W_N^* = \tfrac{1}{2}\theta\omega^2[(2\theta+\hat{\sigma})/(\theta+\hat{\sigma})]^2 > W_N > 0 \tag{6.12}$$

Before we move on to a discussion of the economic intuition behind these results, we present the outcome under international policy coordination. This outcome is obtained by stimultaneously choosing the German money supply (m^*) and the exchange rate (e) to maximize European welfare ($-W-W^*$) and leads to $e_C = 0$, $y_C = y_C^* = y^d$,

$$m_C = m_C^* = \left(\frac{\sigma+\lambda}{\sigma}\right)y^d > m_N^* > m_N, \tag{6.13}$$

$r_C = r_C^* = -y^d/\sigma$, $(w-p_C)_C = (w-p_C)_C^* = 0$ and

$$0 < W_N < W_C = W_C^* = \tfrac{1}{2}\theta\bar{\omega}^2 = \tfrac{1}{2}\theta\omega^2 < W_N^*, \tag{6.14}$$

where the subscript 'C' denotes the cooperative outcome.

To aid the interpretation of the results, let us consider the effects of an adverse common demand shock arising from a European programme of fiscal deflation or, perhaps, from a fall in US demand for European products (say, $f = f^* = d < 0$). Without any adjustment in monetary policies, it is clear from equations (5.3) and (5.4) that employment and output in both countries fall by the same amount ($\partial y/\partial d = \partial y^*/\partial d = \lambda(1+\gamma)/(\sigma+\lambda) > 0$) whilst real income in both countries remain unaffected. This means that, if both countries start from a position of full employment, then a positive target and a zero real-income target ($y^d > 0, \omega = 0$) are warranted. Similarly, also consider the effects of an adverse common supply shock arising from, for example, a common increase in the European tax wedge, a common deterioration in productivity or an increase in oil prices ($\tau = \tau^* = s > 0$). It follows that employment and output throughout Europe fall by the same amount ($\partial y/\partial s = \partial y^*/\partial s = -\sigma/(\sigma+\lambda) < 0$) and that real incomes fall in the same proportion ($\partial(w - p_C)/\partial s = \partial(w^* - p_C^*)/\partial s = -1$), so that both a positive output target ($y^d = \sigma s/(\sigma+\lambda) > 0$) and a positive real-income (or cost-of-living) target ($\omega = s > 0$) are warranted.

It is now possible to summarize the results on coordination of monetary policies within the European Monetary System with the following propositions:

(i) Coordination of monetary policies within Europe leads each central bank to attain full employment exactly, both under a floating and under a managed intra-European exchange rate. In both cases, this is achieved with an equal increase in all European money supplies leading to a fall in the European interest rate, whilst real incomes and the intra-European exchange rates are unaffected. This holds for common shocks in both demand and supply.

(ii) A common demand shock to all European countries leads under a managed intra-European exchange rate and non-cooperation to exactly the same outcomes as under cooperation within Europe.

(iii) A common adverse supply shock to all European economies leads, under a managed intra-European exchange rate and non-cooperation, to an appreciation of the lira, franc and guilder *vis-à-vis* the Deutschmark, even though the European economies have identical structures. Hence, the non-German economies use a real appreciation to disinflate away the adverse consequences of the common supply shock. This is achieved by the Bundesbank expanding its money supply by more than the other European central banks. Germany achieves full employment but does not score at all on its real-income target, whereas the rest of Europe does not score so well on the employment-target but achieves, with the aid of an appreciation, also on the real-income target. It can be shown that the rest of Europe

achieves a smaller welfare loss than Germany, so that the exchange-rate realignment allows the rest of Europe to reduce the damage to its welfare at the expense of Germany. It is even the case that the rest of Europe does better than under coordination, whilst Germany does worse than under coordination.

The beggar-thy-neighbour policy of the rest of Europe, following a common supply shock, works because it has complete control of the intra-European exchange rate. The result under (iii) should be compared with the case of floating exchange rates, discussed in Section 4 (see equation (4.17)) and also discussed in Canzoneri and Gray (1985), where both countries respond with an excessive monetary contraction and futile attempts to export inflation leaving the exchange rate nevertheless unaffected after an adverse supply shock. In fact, when there is no cooperation within Europe, the German money supply is greater under a managed than under a floating intra-European exchange rate. Also, note that cooperation within Europe leads to fixed exchange rates and may therefore facilitate the move towards European Monetary Union. However, intra-European exchange rates need no longer remain fixed when European economies do not have identical structural coefficients, even when the European economies coordinate their monetary policies and are hit by identical shocks (see Basevi and Giavazzi, 1987). This suggests that the completion of a common European market may be a prerequisite for full monetary union within Europe. Also, note that a symmetric regime of irrevocably fixed exchange rates (see Section 5) can mimic the outcomes under international policy coordination because beggar-thy-neighbour policies are ruled out by construction.

Giavazzi and Giovannini (1989) obtain similar results to the ones discussed so far with a model that does not have the real exchange rate affecting real income and thus welfare, but that does have the real exchange rate affecting aggregate supply through the usage of imported intermediate goods. They show that, under non-cooperation, a managed intra-European exchange rate and a country-specific demand shock, it is also possible for Germany to be better, rather than worse, off than the rest of Europe. This result derives from the negative spill-over effects of exchange rate changes which in part relieve Germany from the overcontraction/overexpansion bias in monetary policy under non-cooperative decision making.

7. Concluding Remarks

We started in Section 2 with a regime of irrevocably fixed exchange rates, which is applicable to an analysis of the international conflict over inflation

and the balance of payments under the European Monetary System with German hegemony or, much better, under European Monetary Union. There is a common European inflation rate, which is a weighted average of the European rates of domestic credit expansion (in excess of real growth), and the balance-of-payments ratio for any country is the excess of inflation over its rate of domestic credit expansion. In such a situation the non-cooperative outcome gives a too high (low) European inflation rate when the actual increase in international reserves exceeds (is below) the weighted average of desired balance-of-payments ratios. Hence, an excessive growth in international reserves means that countries defend themselves against reserve accumulation by exporting inflation. The task of a European Central Bank, if it is ever established, is to ensure that the growth in European Currency Units is such that the total growth in international reserves matches the average desire for accumulating reserves by the central banks of the various European countries.

With floating exchange rates, each country can isolate its inflation rate and there is thus no need for international policy coordination on this front. However, if cutting monetary growth must imply raising alternative revenues from distortionary taxes, then Section 3, p. 97, showed that levels of government spending are too high whilst monetary growth rates are too low because higher taxes are a beggar-thy-neighbour policy as they reduce imports and foreign welfare. Under a European Monetary Union the scope for raising seigniorage revenues is much less, so that the international coordination of distortionary taxes becomes an even more pressing issue. Section 3, p. 97, continued with arguing that, under floating exchange rates, an expansion of monetary growth leads to a fall in the world real interest rate and a rise in capital accumulation, employment and output throughout the world (the interdependent Mundell Tobin effect). Since inflation increases at home and nowhere else, no country has a wish to carry the burden of reducing the world interest rate and therefore absence of international policy coordination implies a stale-mate in the sense that inflation, monetary growth and activity are too low whilst real interest rates are too high. A regime of fixed exchange rates reduces these inefficiencies considerably, because all countries share the burden as well as the benefits of an increase in monetary growth and consequently there is much less need for international policy coordination.

Section 4 focuses on floating exchange rates and the problems of nominal wage rigidity and unemployment. A monetary expansion is now a beggar-thy-neighbour policy as far as employment and output are concerned, so that monetary policy is in the absence of coordination too loose when preferences depend on employment and the nominal money supply. However, when preferences depend on employment and real income or the cost of living,

monetary policy is too tight because a monetary contraction is a beggar-thy-neighbour policy as far as real income and the cost of living are concerned. In other words, international cooperation avoids the futile attempts at competitive appreciations of the exchange rate. However, it is easy to show that a European Monetary Union sustains the cooperative outcome and avoids competitive appreciations (Roubini, 1986). Section 5 moves on to an asymmetric regime of fixed intra-European exchange rates in Europe with a German hegemony in monetary policy. This means that Germany fixes the money supply whilst the other countries fix the intra-European exchange rates. A German monetary expansion is a locomotive policy as far as employment and output is concerned, whilst a devaluation of the non-German currencies is a beggar-thy-neighbour policy as far as German employment and output is concerned and reduces real incomes outside Germany and increases German real income. Section 6 first shows that international policy coordination under the European Monetary System yields the same outcome as under floating exchange rates, that is full employment. A common adverse demand shock leads to the same outcome under cooperation as under non-cooperation within the European Monetary System, that is the European Monetary System avoids the need for international policy coordination in the face of demand shocks. A common adverse supply shock leads under a non-cooperatively managed intra-European exchange rate to a real appreciation of the lira, franc and guilder versus the Deutschmark, even when the structures of the economies are identical. Hence, the countries other than Germany use a real appreciation to disinflate the adverse consequences of a supply shock and thereby achieve a smaller welfare loss than Germany.

As far as related studies are concerned, Canzoneri and Gray (1985) argue that the move from Bretton Woods to a managed float can be explained by the recent tendency to have more wage indexation in Europe, the fact that oil prices are fixed in dollars, and the oil-price hike caused by OPEC in 1973. This suggests a fascinating line of research: which international regime is the best substitute for international policy coordination. Kenen (1987) also starts from the premise that international policy coordination is not perfect and asks the question which exchange-rate regimes allow individual governments to achieve their national objectives without coordination. Kenen finds that the outcome in a two-country portfolio-balance model depends on both the nature and origin of the shock and on the prevailing exchange-rate regime, but that fixed exchange rates Pareto-dominate floating exchange rates, in that they obviate the need for international policy coordination, whilst floating exchange rates never dominate a regime of fixed exchange rates (see also McKibbin and Sachs (1986a, b) for such comparisons for fiscal policies). Kenen (1988) extends the analysis to allow for differences in size and behaviour between the two countries.

As far as current research is concerned, there is a great deal of emphasis on dynamics and, in particular, on how expectations and the credibility of monetary policy affect the need for international coordination of monetary policies. This requires the use of differential and/or difference game theory and a clear distinction between open-loop or pre-commitment outcomes, obtained with the aid of Pontryagin's Maximum Principle, and feedback, credible or sub-game perfect outcomes, obtained with the aid of Bellman's Method of Dynamic Programming (see the papers in Buiter and Marston (1985) and in van der Ploeg and de Zeeuw (1989)). The most important point is, as the Appendix argues, that, when central banks have no reputation with the private sector, then international policy coordination destroys the discipline of central banks and can thus be counterproductive (Rogoff, 1985; van der Ploeg, 1988).

Appendix: Micro-foundations and Credibility Problems

Here we will argue that, in contrast to what many laymen think, international policy coordination can be counterproductive as it worsens the credibility of the central banks *vis-à-vis* private sector agents. The point is that, in a two-country world, there are really at least three players, namely the central bank of the home country, the central bank of the foreign country, and the private sector. International coordination of monetary policies implies a coalition between the two central banks, but this coalition can provoke an adverse response from third players, i.e. the private sector. In other words, a coalition among a sub-group of players can worsen the game with the remaining players. Under floating exchange rates each central bank has an incentive to announce a low money supply in order to persuade the private sector to settle for low nominal wages, but once the private sector is locked into such contracts the central bank has an incentive to renege and implement a surprise increase in the money supply. Such a possibility to renege should be excluded in equilibrium, unless central banks can tie their own hands and pre-commit themselves, so that strategies of the central bank should be credible and be believed by the private sector in the sense that they must be rational to carry out if called upon to do so. It is straightforward to show that credible equilibria, relevant when central banks have no reputation or ability to pre-commit themselves, lead to higher monetary growth and inflation rates. The point is that international policy coordination destroys a discipline device and therefore gives central banks a greater incentive to renege (Rogoff, 1985; van der Ploeg, 1988). The reason is that, in the absence of international policy coordination, a surprise inflation tax leads to a depreciation of the currency and inflation costs which acts as a disincentive to renege. The same point can be made with respect to fiscal policies (Kehoe,

1986). However, a European Monetary Union with irrevocably fixed intra-European exchange rates avoids those credibility problems and this is indeed, one of the main attractions of such a system.

To illustrate the above discussion, we will discuss the desirability of international policy coordination with and without pre-commitment or reputation within the context of a classical model of two interdependent monetary economies with micro foundations and a long-run trade-off between inflation and output (cf. van der Ploeg, 1988; Sections 4.2 and 5.1). Micro-foundations allow one to analyse the game-theoretic aspects in a much better way. There are flexible prices, there is imperfect substitution between home and foreign goods, and agents hold only domestic cash in their portfolios. Labour is immobile. The government levies distortionary taxes on income from production and also imposes 'inflation taxes' in order to finance the provision of public goods. The home households maximize their utility,

$$\int_0^\infty \exp(-\delta t)[\alpha_1 \log(C_D) + \alpha_2 \log(C_M) + \alpha_3 \log(1 - l^s) + \alpha_4 \log(G) + v(M)]dt,$$
$$\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 = 1,\ \alpha_i \geqslant 0,\ v''(m) > 0, \qquad \text{(A.1)}$$

subject to their budget constraint,

$$\dot{m} = (1 - \tau)(wl^s + z) - C_D - eC_M - \pi M, \qquad \text{(A.2)}$$

where δ, C_D, C_M, l^s, G, M, τ, w, z, e and π denote the pure rate of time preference, consumption of home goods, consumption of foreign goods, labour supply, public spending, real money balances, the tax rate, the real wage, profits, the exchange rate and the inflation rate, respectively. Application of Pontryagin's Maximum Principle yields $C_D = \alpha_1/\lambda$, $C_M = \alpha_2/e\lambda$, $l^s = 1 - \alpha_3/[(1 - \tau)w\lambda]$ and

$$\dot{\lambda} = (\delta + \pi^e)\lambda + v'(M) \qquad \text{(A.3)}$$

where λ denotes the marginal value of money balances and π^e denotes expected inflation. Putting money in the utility function gives us a demand for money, which is a negative function of inflation. There exists an M, say M_F, such that $v'(M) = 0$ and this will be called Friedman's optimal quantity of money (OQM). Firms maximize profits, which gives the demand for labour, l^d, from, $f'(l^d) = w$ where f(.) is the production function. Labour market equilibrium gives employment $l = 1 - \alpha_3/[(1 - \tau)f'(l)\lambda]$, which can be solved to give $l = L((1 - \tau)\lambda)$, $L' > 0$. Money market equilibrium gives $\mu = \pi + \dot{M}/M$, where μ denotes the growth in the nominal money supply.

The government budget constraint is given by $\mu M = d \equiv G - \tau f(l)$, where d denotes the public sector deficit. The foreign economy has identical tastes and preferences and the same population size. Foreign variables are denoted with an asterisk. Goods market equilibrium is given by $f(l) = C_D + G + C_M^*$, where C_M^* denotes exports. Exchange market equilibrium gives $C_M^* = eC_M$, so that $e = \lambda/\lambda^*$. Finally, perfect foresight gives $\pi^e = \pi$. The perfect-foresight equilibrium (PFE) gives the endogenous variables conditional on expectations of current and future values of the government's policy instruments. In particular, the demand for real money balances depends negatively on the expected inflation rate, as in a Cagan-type money-demand schedule, and therefore the price level is history-dependent and jumps in reaction to 'news' about future events. Hence, real money balances also change instantaneously in response to 'news'. The objective of each government is to choose its fiscal and monetary policies (τ, G and μ) to maximize the utility of the representative household subject to the constraints of the PFE.

Before we proceed to a discussion of the decentralized market outcomes under non-cooperative central banks and under international policy coordination, we briefly discuss the first-best outcome of the world economy as this gives an upper bound on the welfare that can be obtained in a system of cooperative or non-cooperative interdependent market economies. The first-best optimum for the world economy is characterized by (see also Section 3, p. 96): (i) the marginal rate of substitution between home and foreign consumption of home, public and foreign goods is unity ($\alpha_1/C_D = \alpha_2/C_M = \alpha_3/G = \alpha_1/C_D^* = \alpha_2/C_M^* = \alpha_3/G^*$); (ii) zero tax distortions ($\tau = \tau^* = 0$); and (iii) Friedman's Optimum Quantity of Money ($M = M^* = M_F$). The implied monetary growth rate is $\mu = G/M_F$, so that the full liquidity rule of zero nominal interest rates, i.e. $\mu = -\delta$, does not even hold in a first-best optimum for the world economy. For linear technologies, $f(l) = \beta l$, one obtains $C_D = C_D^* = \alpha_1\beta$, $C_M = C_M^* = \alpha_2\beta$, $G = G^* = \alpha_4\beta$, $1 - l = 1 - l^* = \alpha_3$ and $\mu = \mu^* = \alpha_4\beta/M_F$.

We now move back to the decentralized market outcomes associated with the perfect-foresight equilibrium. We already mentioned the forward-looking character of real money balances. This means that the central bank or Treasury of each country can announce a change in policy at some future event and, if believed by the private sector, then the private sector will respond today. The credibility problems arising from these intertemporal linkages give rise to a game between each government and private sector agents. There is also a game between the home and foreign government arising from the externalities induced by changes in foreign policy. An increase in the foreign tax rate or foreign level of public spending leads to a reduction in the foreign demand for home goods. The incipient trade deficit is choked off by a depreciation of the home market exchange rate, which

reduces home consumption of foreign goods and therefore worsens home welfare (also see Section 3.1). This is the externality facing home and foreign governments.

Four market outcomes can be considered:

(i) Non-cooperation between home and foreign governments, but pre-commitment or reputation *vis-à-vis* private sector agents.
(ii) International policy coordination and pre-commitment or reputation *vis-à-vis* private sector agents.
(iii) Non-cooperation between home and foreign governments and lack of credibility *vis-à-vis* private sector agents.
(iv) International policy coordination and lack of credibility *vis-à-vis* private sector agents.

In outcome (i) governments do not cooperate in their choice of tax rates, levels of government spending and monetary growth. Furthermore, each government pre-commits itself to the announced policies for the future. This pre-commitment can be done through constitutional law, institutional constraints or the build-up of a reputation for 'sticking to your guns'. In other words, private sector agents believe the governments and act accordingly. It can be easily shown that pre-commitment is required, because the non-cooperative outcomes under (i) are time inconsistent as each government has an incentive to cut distortionary taxes and increase monetary growth and inflation in order to erode the real value of money balances and thus increase welfare. The rationale behind this incentive to renege is that the increase in seigniorage revenues permits a cut in distortionary taxes, leading to more employment, and an increase in government spending, both of which improve welfare. This time inconsistency arises despite the fact that there is no conflict between private and public objectives! If there are no binding contracts or reputational forces that prevent each government from reneging on its private sector, expectations will not be fulfilled and the government will soon lose its credibility. In that case, outcome (iii) becomes relevant and the government has to treat its price level or, alternatively, its shock of real money balances as a predetermined rather than as a jump variable. Hence, this has been coined the non-cooperative, 'loss of leadership' outcome as each government is resigned to the fact that it has no reputation and cannot manipulate the holdings of real money balances. It is easily shown that outcome (iii) leads to higher tax rates and the resulting distortions in relative prices reduce the opportunity cost of leisure, so that labour supply is less. Also, output and the consumption of home and foreign goods is less than under outcome (i) (and thus *a fortiori* less than in the first-best outcome for the world economy). The main feature of the non-cooperative outcome

without pre-commitment or reputation, outcome (iii), is, however, that real money balances are lower than under outcome (i), because then the governments will have no incentive to renege and impose a surprise inflation tax. Clearly, outcome (iii) always yields lower welfare than the non-cooperative outcome with pre-commitment (i).

Now consider outcome (ii), that is the outcome under international policy coordination with pre-commitment or reputation *vis-à-vis* private sector agents. The main difference with the non-cooperative outcome with pre-commitment, (i), is that the negative externalities of higher taxes and public spending on foreign welfare will be internalized, that is international policy coordination leads to lower taxes and public spending than outcome (i). It is easily shown that international policy coordination still leads to the problem of time inconsistency, that is both governments have a joint incentive to renege on private sector agents. In fact, there is a greater incentive to renege than under the non-cooperative outcome, (i), and therefore an even greater need to have binding contracts or reputation. The reason is that *international policy coordination destroys to a large extent the monetary discipline of central banks*. Non-cooperative policies have a built-in disincentive to renege, i.e. discipline device, because a surprise levy of an inflation tax immediately leads to a depreciation of the real exchange rate and the associated inflation reduces welfare and acts as a disincentive to renege. International policy coordination no longer has this built-in disincentive to renege on private sector agents, because when both governments impose a joint surprise inflation tax the exchange rate is unaffected and the associated discipline device is demolished. The above discussion explains why international policy coordination with central banks who lack credibility *vis-à-vis* their private sector agents, i.e. outcome (iv), leads to excessive monetary growth and inflation rates and thus to very low levels of real money balances; low levels of monetary growth would simply not be believed by private sector agents who fear a surprise inflation tax. The high inflation reduces welfare and is the main reason why international policy coordination, when central banks lack credibility with private sector agents, can be counterproductive. There is an off-setting effect, which has to do with the fact that outcome (iv) has no distortionary taxes ($\tau = \tau^* = 0$) and that the provision of public goods is less than in the non-cooperative outcome, (iii), ($G_C = G_C^* = \alpha_4\beta < G_N$). Hence, the fiscal policy instruments in the cooperative outcome, (iv), are exactly the same as in the first-best outcome for the world economy. International policy coordination is counterproductive, when the adverse welfare effects of excessive monetary growth and inflation (caused by lack of credibility) outweigh the beneficial welfare effects of no tax distortions and optimal provision of public goods.

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